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REPORT OF G-PROTECTION PHYSIOLOGY RESEARCH RELATED TO EXTENDED COVERAGE G-TROUSERS WITH PRESSURE BREATHING ON HUMAN VOLUNTEERS UNDER G-LOADS ON THE HUMAN CENTRIFUGE AT AL/CFTF, BROOKS AFB, TEXAS DONE BY ULF BALLDIN, M.D., PH..D. , NATIONAL DEFENCE RESEARCH ESTABLISHMENT, SWEDEN DURING THE PERIOD MARCH 23, 1993 TO MARCH 14, 1994.

The research involving the Swedish Tactical Flight Combat Suit with extended coverage anti-G trousers with pressure breathing during G, where two different anti-G trouser pressures were compared as well as comparisons to the USAF COMBAT EDGE and ATAGS equipment were finally analyzed and submitted for publication in Aviat. Space Environ. Med. (1).

During the studies the muscular activity was also analyzed using the EMG-technique. The increased performance with TFCS with full pressure compared to with reduced pressure can not be due to powerful anti-G straining maneuvers but to better suit protection. During the rapid onset run G-profiles the muscular technique seems to be important in addition to the suit. The results were presented at the 1994 Aerospace Medical Association Meeting (2). Further analyzes are currently going on and a manuscript in preparation.

To improve the comfort of pilots wearing the Swedish extended coverage anti-G suit outside the aircraft during hot days -- when immersion protection is not necessary -- a summer flight suit was developed that eliminated the

immersion suit. With this system, the suit is worn directly over an ordinary flight suit. This condition was compared to the standard ensemble of a ventilated immersion suit and heavy undergarment worn under the extended coverage suit. G-tolerances of six Swedish AF pilots were determined in gradual onset, rapid onset and simulated aerial combat maneuver (SACM) G-profiles up to 9 +Gz on the AL/CFTF centrifuge. No significant differences were found between the two experimental conditions regarding operational G-tolerances, eye level blood pressure, heart rate, or ventilation flow. Also, ratings of perceived exertion during the SACM, as well as subjective ratings of G-tolerance, fatigue, and overall comfort did not statistically differ. A significant difference was found with lower subjective heat stress, as anticipated, with the summer flight suit ensemble. The efficacy of the extended coverage anti-G suit to transmit pressure to the legs and abdomen, when worn over the immersion suit and heavy undergarment was maintained since G-protection was not reduced. The results were presented at the 1994 SAFE SYMPOSIUM and published in the SAFE JOURNAL (3).

In some pilots the use of pressure breathing during G in combination with the extended coverage anti-G suit may cause the abdominal bladder to expand upward and inward and generate discomfort and pain. An internal abdominal bladder restraint was introduced in the Swedish Tactical Flight Combat Suit and tested in the AL/CFTF centrifuge with Swedish AF fighter pilots as subjects. All subjects were able to maintain 60 s at 9 +Gz during gradual onset and rapid onset runs with and without abdominal bladder restraint. No difference was found during the simulated aerial combat maneuver G-profile. The ratings of perceived exertion, subjective G-tolerance, and overall comfort were not fount different with and without abdominal bladder restraint, why it seems possible to modify the anti-G suit abdominal bladder with this internal restraint without compromising the operational G-tolerance. The results are accepted to be presented at the 1995 Aerospace Medical Association meeting (4).

G-induced arm pain and petechiae are conditions that may be experienced by centrifuge subjects or pilots during extended or repeated periods of high G-loads with and without pressure breathing equipment. An experimental model has been developed to provoke arm pain by exposing subjects to increased ambient pressure in a hyperbaric chamber with an arm extended through a special opening and maintained at normal atmospheric pressure. Blood is forced out into the arm and venous return is hindered, creating

venous congestion and ultimately causing arm pain, similar to G-induced arm pain. Sealing of the arm in the chamber door was accomplished by an adjustable "camera iris" opening that did not interfere with the blood flow. Regional volumes of the arm were determined by impedance plethysmography. Blood vessel size and blood flow were determined by sonography. Finger blood pressure was determined by Finapres. Preliminary results indicate that with a 100 mmHg pressure increase in the chamber, arm pain was provoked after 5 to 10 minutes. With higher pressure arm pain was very strong and developed earlier. The method seem to be an excellent method to simulate and study G-induced arm pain: it provides better physiological data than centrifuge-induced arm pain. Countermeasures to reduce arm pain are easier to test with this technique. The results of this methodological development has been presented at the 42nd International Congress of Aviation and Space Medicine in New Delhi, India 1994 (5) and a manuscript has been accepted for publication in Indian Journal of Aviation Medicine (6).
Further studies of the mechanisms behind G-induced arm pain and countermeasures to prevent it are currently going on.

The results of the cooperative studies between AL/CFTF, Texas Lutheran College and National Defence Research Establishment, Sweden concerning echocardiographic assessment of right ventricular response following release of simulated +Gz stress and cerebral artery blood flow velocity changes following removal of presyncopal simulated high +Gz stress are analyzed and presented at the 1994 Aerospace Medical Association Meeting (7, 8). A manuscript of the latter study is submitted to Aviat. Space Environ Med. (9).

REFERENCES

1. Krock LP, UI Balldin, K Harms-Ringdahl, C Singstad, J Linder, J Siegborn. Influence of a modified filling pressure schedule on G-tolerance with enhanced G protection ensembles. Submitted for publication to Aviat. Space Environ. Med.

2. Harms-Ringdahl K, J Linder, J Siegborn, U Balldin, L Krock. Muscular activity during anti-G straining maneruvres in human centrifuge runs. (Abstract). Aviat. Space Environ. Med. 1994; 65: 448.

3. Balldin UI, LP Krock, J Linder, J Siegborn. Operational G-tolerance is not decreased with an immersion protection garment worn under the extended coverage anti-G suit. SAFE JOURNAL. 1994; 24 (3): 24-28.

4. Balldin UI, LP Krock, PG Larsson. Operational acceleration tolerance with the Swedish extended coverage G-suit using PBG with and without internal abdominal bladder restraint. Accepted for publication as an abstract in Aviat. Space Environ. Med. 1995.

5. Balldin UI, LP Krock. Use of a hyperbaric chamber to produce simulated G-induced arm pain. (Abstract). In Programme and Abstracts, 42 nd International Congress of Aviation and Space Medicine, New Delhi, India, 1994: 36.

6. Balldin UI, LP Krock. Use of a hyperbaric chamber to produce simulated G-induced arm pain. Accepted for publication in Indian Journal of Aviation Medicine.

7. Krock LP, UI Balldin, NL Hopper, DA Ludwig, WG Squires. Echocardiographic assessment of right ventricular response following release of simulated +Gz stress. (Abstract). Aviat. Space Environ. Med. 1994; 65:441.

8. Balldin UI, LP Krock, NL Hopper, WG Squires. Cerebral artery blood flow velocity changes following removal of presyncopal simulated high +Gz stress. (Abstract). Aviat. Space Environ. Med. 1994; 65:446.

9. Balldin UI, LP Krock, NL Hopper, WG Squires. Cerebral artery blood flow velocity changes following rapid release of lower body negative pressure. Submitted for publication in Aviat. Space Environ. Med.